INFORMATIONAL LEAFLET NO. 158

FORECAST OF THE 1972 PINK SALMON RUNS,

SOUTHEASTERN ALASKA

By

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ERRATA SHEET FOR INFORMATIONAL LEAFLET NO. 158

On pages 36 and 38 the formula for the standard error of prediction $s_{Y \cdot}$ should read

$$s_{Y \cdot} = s_{Y.X} \sqrt{1 + \frac{1}{n} + \frac{(X - \overline{X})^2}{\Sigma (X - \overline{X})^2}}$$

rather than

$$s_{Y.} = s_{Y.X} \sqrt{1 + \frac{1}{n} + \frac{(\hat{Y} - \overline{X})^2}{\Sigma (X - \overline{X})^2}}$$

This change results in changes in the prediction intervals as follows:

Southern Southeastern	Original	Corrected
90 percent confidence interval	8.90 - 18.58	10.64 - 16.80
80 percent confidence interval	10.36 - 17.08	11.57 - 15.87
Northern Southeastern		
90 percent confidence interval	4.53 - 21.19	5.99 - 19.73
80 percent confidence interval	7.06 - 18.66	8.08 - 17.64

FORECAST OF THE 1972 PINK SALMON RUNS, SOUTHEASTERN ALASKA[1/]

By

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ABSTRACT

Results of the 1971 pre-emergent fry sampling indicate a return in 1972 of 13.7 million pink salmon to southern Southeastern and a return of 12.9 million to northern Southeastern for a total return of 26.6 million pinks. Although the total magnitude of the run appears relatively strong, the forecast by district and timing segments indicates that returns to certain areas will be very weak. The harvest in southern and northern Southeastern Alaska is expected to be approximately 7.7 million and 8.9 million respectively.

INTRODUCTION

The purpose of this report is to present the 1972 pink salmon forecast, analyze the success of the 1971 forecast, and provide a single source of reference for data used to forecast runs to Southeastern Alaska prior to and including 1972. This report is the seventh in a series concerning forecast studies in Southeastern Alaska (Noerenberg, et al., 1964; Hoffman 1965, 1966; Smedley and Seibel, 1967, Smedley, 1968; Valentine, et al., 1970).

Annual pink salmon forecasts are of importance to the fishing industry, both fishermen and processors, and to fishery managers for operational planning and regulatory decision making.

The primary objective of this program is to accurately predict: (1) the magnitude of the total run, (2) the magnitude by timing of the various segments of the run, and (3) the magnitude of the district runs. From these predictions, estimates of expected harvest levels can be made.

Southeastern Alaska, for the purpose of pink salmon forecasting, is divided into two parts, northern Southeastern and southern Southeastern (Figure 1), resulting in two separate forecasts. Tagging studies have indicated that upon entering the offshore waters of Southeastern Alaska pink salmon separate into two groups, the northern group entering via Icy Strait and the lower Chatham Strait and the southern group entering via Sumner Strait and Dixon Entrance.

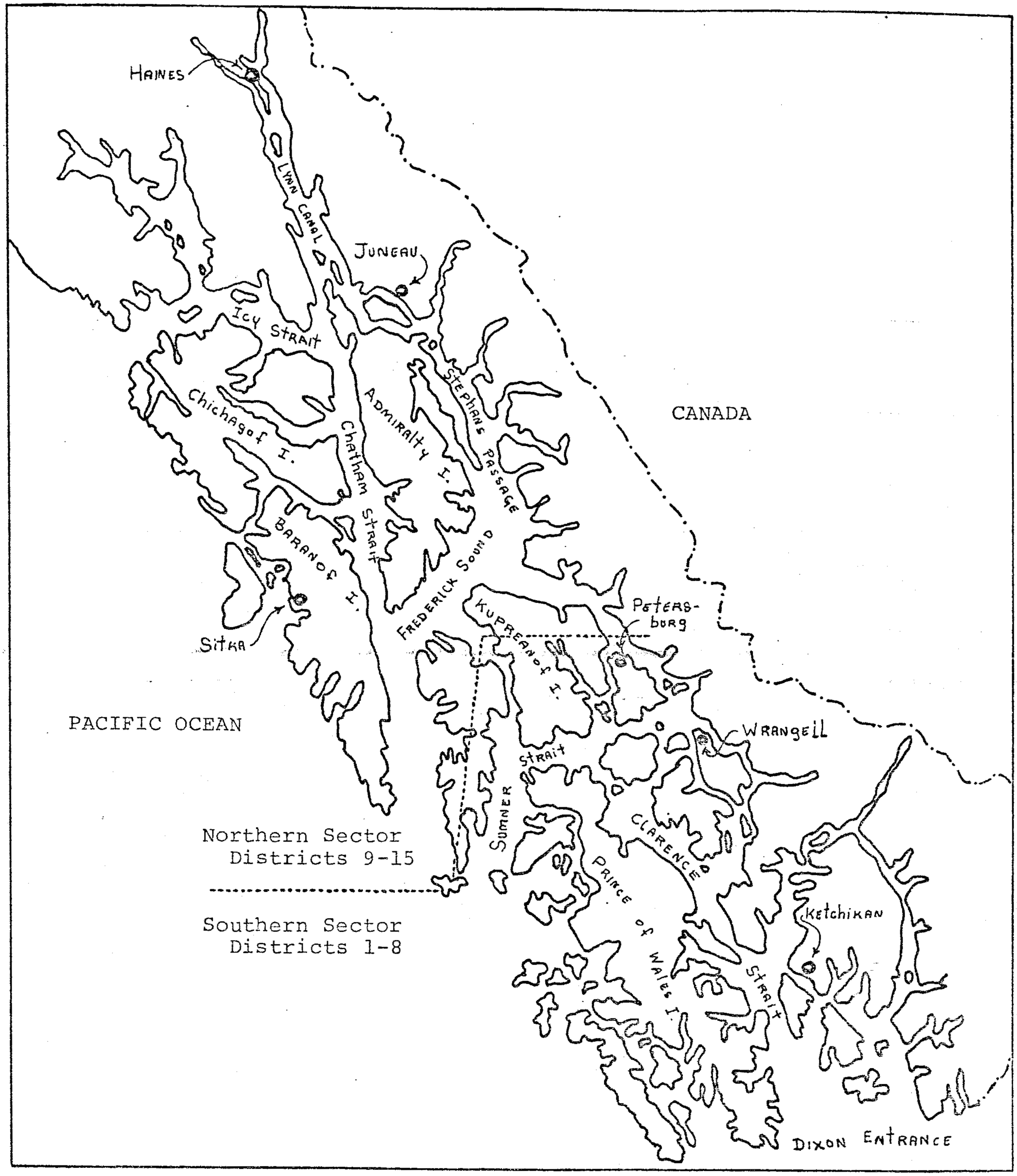


Figure 1. Map of Southeastern Alaska showing division between northern and southern areas.

Southeastern Alaska is also divided into 15 regulatory districts (Figure 2) for which forecasts are also provided.

Pink salmon forecasts are based on the relationship between pre-emergent fry abundance and subsequent adult return. Studies conducted in other areas of Alaska, in particular Prince William Sound, have demonstrated that annual variations in estuarine and ocean mortalities are, on the average, small enough to permit forecasting of pink salmon returns on the basis of pre-emergent fry abundance with sufficient accuracy to be of value for fisheries management and industry use.

HISTORICAL PATTERNS IN SOUTHEASTERN ALASKA PINK SALMON RUNS

The significance of recent trends in Southeastern Alaska pink salmon runs can be properly discussed only in relation to longer term historical patterns of these runs. Because data on annual escapements prior to 1960 is very limited, it is necessary to use annual commercial harvest data as an indirect measure of annual run size in the discussion of historical patterns. This procedure, although frequently used, has certain limitations and interpretations of such data must be made cautiously. Variations in numbers of units of gear, gear efficiency, fishing time, fishing districts and other factors prevent one from directly assuming that annual harvests are proportional to either escapements or total runs.

Measures of Annual Escapement

Because the term escapement frequently occurs in the following discussions and because of its importance in salmon management, it is appropriate to include a brief explanation of the term at this point.

The term escapement is normally used in reference to those salmon which, having survived natural and harvest mortalities, reach the spawning grounds and become part of the spawning population. More technically, escapement is sometimes used to designate those fish which have passed through the commercial fishery and are enroute to the spawning grounds. However, since the natural mortality rate of mature fish is relatively small this use of the term agrees closely with that given above. The term escapement is also used to represent the number of fish in a spawning population as opposed to the spawning population itself.

One other very important use of the term escapement is as an abbre-

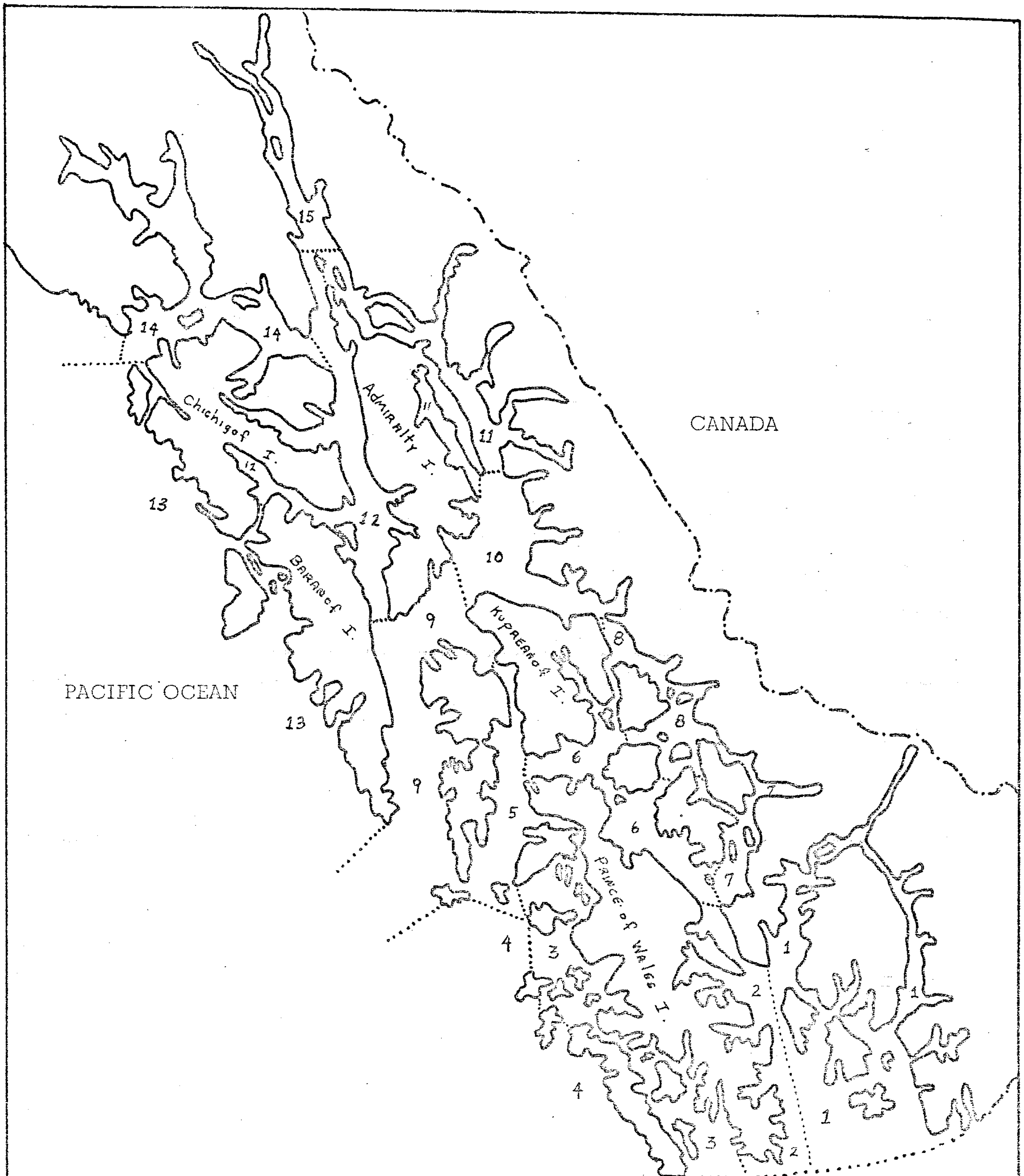


Figure 2. Map of Southeastern Alaska showing regulatory districts.

viation for 'escapement index'. In many of the salmon fisheries throughout the state it would be difficult, and the cost prohibitive, to obtain estimates of total escapement (or number of spawners) each year. This is especially true in an area such as Southeastern Alaska where spawning pink salmon utilize several thousand streams. As an alternative to estimating the total number of spawners, an index or relative measure of escapement is obtained. This is accomplished by estimating escapements to a number of streams which receive a large and relatively constant proportion of the total area escapement, as is required to validate the use of an escapement index as opposed to an estimate of total escapement. Relative changes in total escapement from year to year must be reflected by similar relative changes in the escapement index. For example, a twofold increase in total escapement should be reflected by a twofold increase in the escapement index. If the above relationship between total escapement and an escapement index is satisfied, the escapement index can be substituted for total escapement for in-season management and for estimating optimum escapement, maximum sustained harvest and other parameters used in salmon management.

Another important characteristic of an escapement index becomes apparent if the set of index streams (those streams for which escapement estimates are combined to form the escapement index) is well chosen. Estimates of escapement to these streams provide a measure of relative spawning density for the non-index streams which are not actually surveyed for escapement.

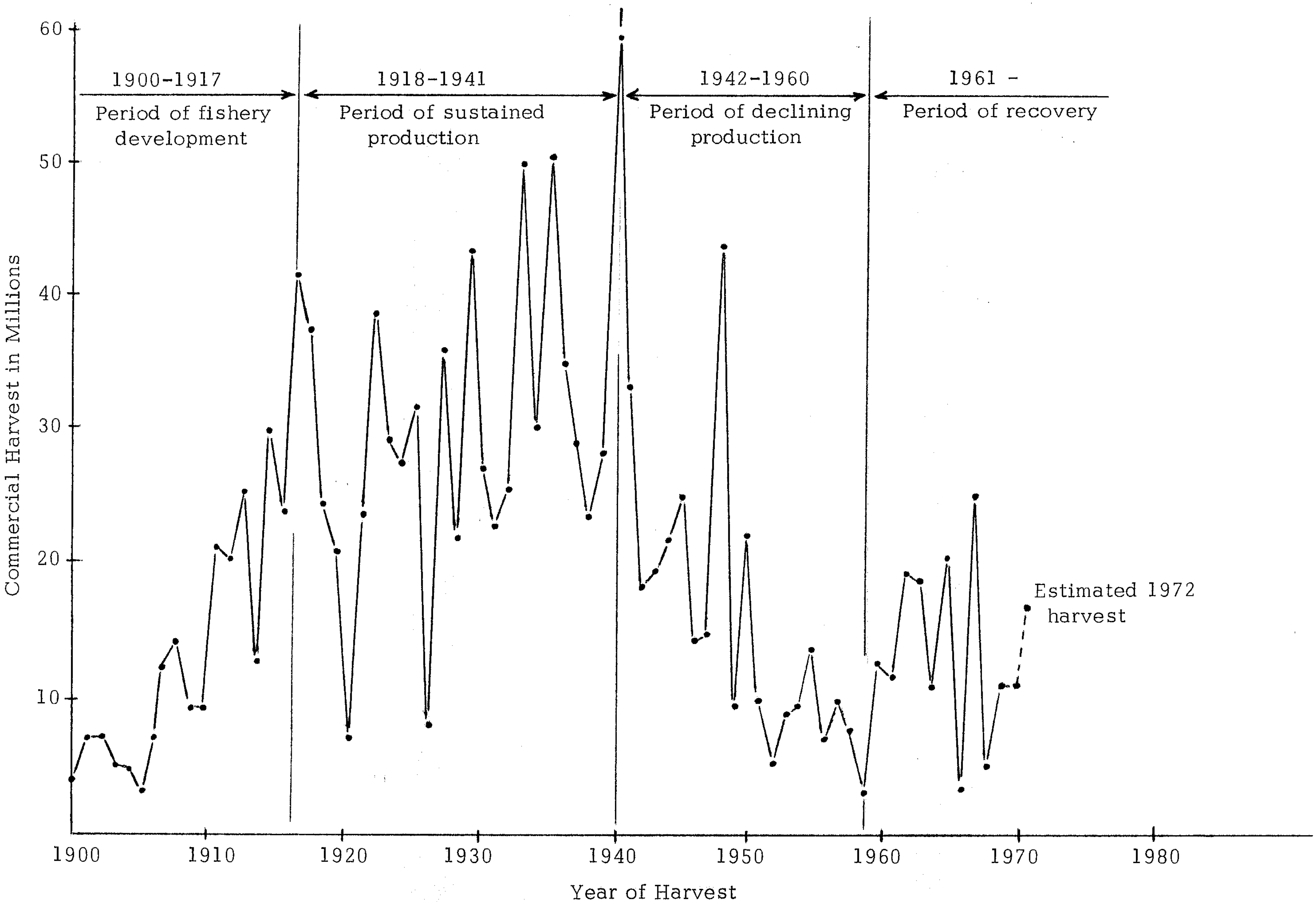
Historical Patterns of Commercial Harvests Since 1900

Although Alaska's commercial salmon fisheries began in the late 1800's, annual commercial harvests in most areas of the state did not reach significant proportions until after the turn of the century. Annual commercial harvests of pink salmon in Southeastern Alaska, since 1900, are shown in Figure 3. This figure suggests that, similar to other major Alaskan salmon fisheries, the Southeastern Alaska pink salmon fishery experienced four basic periods. (Specific beginning and ending dates of each period were chosen arbitrarily and are not of special significance.)

The first period, beginning with the commencement of a commercial fishery and ending about 1917, could be called the period of development. During this period, participation in the fishery, fishing gear and processing facilities increased with a corresponding increase in commercial harvests. The harvest of pink salmon increased from approximately 4 million in 1900 to 41 million in 1917.

Figure 3.

ANNUAL COMMERCIAL HARVEST OF PINK SALMON IN SOUTHEASTERN ALASKA SINCE 1900



The second period, beginning about 1918 and lasting until about 1941, could be referred to as a period of sustained production. During this period the commercial catches, although reflecting large annual variations, appeared to have a relatively constant long term trend neither increasing nor decreasing, with the exception of a slight increase during the latter years of the period. The relatively constant trend for the major part of the period is more apparent if the smaller catches in 1921 and 1927 and the larger catches in 1934, 1936, and 1941 are temporarily ignored. This period of the fishery will be discussed further in another section.

During the third period, 1942-1960, a severe decline occurred in the harvest of pink salmon. Annual pink salmon catches declined steadily from 33 million in 1942 to 3 million in 1960 with the exception of one year's recovery in 1949. During this same period other major salmon fisheries throughout the state experienced similar declines, some less severe and some more severe. The reasons for the decline of nearly twenty years are not immediately apparent without a more elaborate study of the history of these fisheries, however the most probable major cause was repeated over-harvest with the subsequent reduction in spawning populations.

The fourth period, optimistically referred to as the period of recovery, began in 1961. In comparison to the harvest levels in the late 1950's, commercial harvests of pink salmon have increased since 1961. The questions of utmost importance to fisheries managers are (1) how best can the apparent recovery of these fisheries be nurtured and (2) at what highest level can harvests be sustained.

The only major factor, affecting potential harvest from Southeastern Alaska pink salmon stocks, which can presently be controlled by fisheries managers is the magnitude and distribution of annual spawning populations. Other techniques for increasing production, such as controlled hatching and/or created rearing environments have yet to be evaluated. Intensive efforts are, therefore, being made to (1) study escapement requirements, and when necessary, revise existing escapement goals, and (2) improve existing and develop new in-season management techniques for achieving desired escapement goals.

Trends in Total Runs Since 1960

Mature salmon returning in a given year to inshore waters from ocean rearing areas are normally referred to as the 'run' or 'return' with the term 'total' sometimes being prefixed to emphasize that reference is being made to all fish returning, whether they are harvested or reach the spawning grounds. The total run consists of harvest plus escapement. Therefore, estimates of total runs are dependent on estimates of harvest and escapements. The number of salmon harvested each year is obtained from fish tickets which are completed when fishermen deliver salmon to tenders, scows or directly to processing plants.

As indicated above, it is impractical to obtain estimates of the total number of pink salmon spawning in Southeastern Alaska each year. As an alternative, an index or relative measure of spawner abundance is obtained by estimating the annual escapement to a set of index streams responsible for a relatively large proportion of the total Southeastern Alaska pink salmon production. Under the assumption that the cumulative escapement to streams not included in the set of index streams is approximately proportional to the cumulative escapement to the set of index streams, the escapement index can be used in place of total escapement estimates for management purposes. Consequently, when the term escapement is used in following discussions it is to be understood that this refers to escapement index.

Pink salmon have a 2-year life cycle, therefore two genetically distinct lines occur. These lines are called "even-year" or "odd-year" depending on the parity of the year in which adults spawn.

Estimates of total returns (harvest plus escapement index) are available for Southeastern Alaska pink salmon since 1960 (Table 1). It should be noted that because the 'total return' consists of harvest plus escapement index, it is in fact an index or relative measure of the true or actual total return in the same sense that the escapement index is an index or relative measure of the true or actual escapement.

Even-year pink salmon runs have been increasing since 1960, except for 1970 when a poor return apparently resulted from high fry mortality caused by the severe winter conditions of 1968-69. Forecast studies indicate that runs returning in 1972 should be substantially greater than those in 1970.

Odd-year pink stocks have been at a low level of production since 1967 following the severe drought condition during August and September, 1965 greatly reduced the production of fry. Through strict regulatory measures and cooperation of the fishing industry, the odd-year stocks have dramatically increased and may be approaching the magnitude of the generally good even-year runs.

Escapements into streams throughout Southeastern Alaska during even-numbered years have been increasing since 1960, except in 1970 when escapements dropped slightly (Table 1). Escapements in the odd-years 1965, 1967, and 1969 remained considerably below recent even-year escapement levels, however the 1971 escapement index of 7.6 million spawners has been exceeded by only two years, 1966 and 1968, since 1960.

Table 1. Southeastern Alaska pink salmon escapement[1], catch, and total run in thousands of fish, 1960-1971.

	Southern Southeastern			Northern Southeastern			All Southeastern		
Year	Escapement	Catch	Run	Escapement	Catch	Run	Escapement	Catch	Run
1960	1,927	1,542	3,469	998	1,429	2,427	2,925	2,971	5,896
1961	2,355	3,875	6,230	2,329	8,698	11,027	4,684	12,573	17,257
1962	4,235	11,007	15,242	1,490	550	2,040	5,725	11,557	17,282
1963	3,915	5,145	9,060	3,589	13,921	17,510	7,504	19,066	26,570
1964	4,745	11,258	16,006	1,954	7,282	9,236	6,699	18,540	25,239
1965	2,944	5,710	8,654	2,422	5,165	7,587	5,366	10,875	16,241
1966	5,402	15,650	21,052	2,653	4,787	7,440	8,055	20,437	28,492
1967	1,506	642	2,148	1,636	2,437	4,073	3,142	3,079	6,221
1968	5,405	15,201	20,606	2,722	9,882	12,604	8,117	25,083	33,200
1969	2,014	1,160	3,174	2,197	3,594	5,791	4,211	4,709	8,920
1970	4,267	5,412	9,679	2,317	5,239	7,556	6,584	10,651	17,235
1971[2]	4,971	6,050	11,021	2,614	2,890	5,504	7,585	8,940	16,525

1/ Escapement indices used as measures of relative magnitudes of actual escapement.
2/ 1971 catch figures are preliminary.

The generally increasing trend in recent escapements reflects intensive efforts by the Department to maintain, and if possible accelerate, the upward trend occurring in Southeastern pink salmon stocks. Recent increases in harvest levels tend to underestimate the actual rate of increase in stock abundance because the larger escapements obtained, while representing increased future potential, restrict present harvest levels.

SUCCESS OF 1971 FORECAST

Success of the 1971 forecast and how it compares to past years results are summarized (Table 2). In southern Southeastern the actual return of 11.0 million pinks was 6.7 million greater than the predicted level of 4.3 million. In northern Southeastern the actual return of 5.5 million was 3 million less than the predicted level of 8.5 million.

The forecast error for southern Southeastern has varied considerably since 1967; from 0 to 118%. The 60% error in the 1971 forecast was largely the result of insufficient data for proper analysis. At the time the 1971 forecast was developed it was believed that escapement-return data for the odd- and even-years should be analyzed separately because of a supposed difference in the relationships between fry densities and returning runs of previous odd- and even-years. Since the forecast studies started the odd-year runs have been slight and the resultant fry densities low. We are finding that with the buildup of odd-year runs the resultant fry values are increasing and appear to produce returns similar to even-year runs. In southern Southeastern, for example, odd-years data were originally used to forecast the 1971 return. If both odd- and even-year data had been utilized the forecast would have been 10.5 million, which is only 0.5 million less fish than the actual run.

In northern Southeastern the percent error of forecast has varied from 18 to 55%. The 1971 error was 55%, the greatest since forecasting began in 1965.

Actual returns to districts in 1971 appeared to differ considerably from predicted returns. This would be expected, of course, in view of the fact that the forecasts to northern and southern Southeastern reflected substantial errors and these forecasts were the direct basis for the district forecasts. The relative size of returns to the various districts in 1971 appeared to correspond closely to the district forecasts, although harvests of mixed stocks make it difficult to determine total returns to districts. In spite of the difficulties in estimating total returns to districts, and consequently, in evaluating the accuracy of district forecasts, these forecasts do provide additional information on probable areas of especially strong or weak returns.

Table 2. Comparison of forecast and actual returns of pink salmon for northern and southern Southeastern Alaska, 1967-1971 (in millions of salmon).

Return year	Predicted return	Actual return	Forecast Error Number	Forecast Error Percent 1/
		Southern Southeastern		
1967	4.8	2.2	+2.6	+118
1968	21.5	20.6	+0.9	+ 4
1969	3.2	3.2	+0.0	0
1970	18.7	9.7	+9.0	+ 93
1971	4.3	11.0	-6.7	- 61
		Northern Southeastern		
1967	4.9	4.1	+0.8	+ 20
1968	6.2	12.6	-6.4	- 51
1969	4.0	5.8	-1.8	- 31
1970	9.0	7.6	+1.4	+ 18
1971	8.5	5.5	+3.0	+ 55

1/ Percent forecast error is defined by

$$\frac{\text{Predicted Return - Actual Return}}{\text{Actual Return}} \times 100$$

1972 PINK SALMON FORECAST

1971 Pre-emergent Fry Sampling Methods and Results

The standard technique employed to enable forecasting has been hydraulic sampling of pre-emergent fry in the spawning riffles during the spring months. Spawning riffles in important and accessible streams are excavated in a manner which should give reliable year-to-year comparisons of relative fry abundance. Sampling is conducted just prior to fry migration to salt water, and when early freshwater mortality is no longer a major consideration. All excavated fry are counted and then related to the number of samples dug and the prior years' escapement into the streams to arrive at an index of abundance.

The set of streams sampled annually is a set of index streams which remains nearly the same and is not composed of streams selected at random each year, for several weighting factors must be employed. First, the fry index for a given district is obtained by dividing the total number of fry collected while sampling in the district by the total number of samples taken in the district. This procedure results in weighting stream indices according to sampling effort; sampling effort is approximately proportional to stream production potential. The district fry indices are then weighted by the district average escapement for the past 5 years thus weighting district indices by measures of their relative production potentials. In both the above weighting procedures, indirect measures of production potential of streams and district are used, however, in conjunction with optimum escapement studies, attempts are being made to develop direct estimates of production potential of individual streams.

Study streams and areas within study streams have changed somewhat over the past 6 years; however, the number of index streams has been stabilized at about 100 in recent years. In a continuing effort to upgrade the forecast, better coverage within the large streams is being achieved by sampling select spawning riffles throughout the length of the streams, thereby covering segments of the entire distribution of the spawning populations. Upstream areas of the larger streams generally provide the greater portion of productive spawning area and, therefore, to provide a total production index, should be sampled along with the lower reaches of the streams. Until recently many of the larger index streams had sample areas only in the easily accessible intertidal and lower stream areas; however, refinements leading toward lighter, more efficient gear and increased use of helicopters have improved coverage, thus increasing the quality and quantity of sampling.

Changes in continuity of data has occurred as the result of adding and deleting sample areas and streams over the past 6 years, so all pre-emergent fry data was adjusted to insure comparability of indices between years (Appendix A). This was accomplished by reviewing all data for the years 1966-1971 and selecting the fry data for the areas and streams which have been sampled the most consistently over the years. As more years of fry data are accumulated and the sample areas become more established, fewer adjustments will have to be made.

The pre-emergent index streams receive approximately 50% of the escapement to Southeastern Alaska. Therefore, they can be said to produce roughly half of the returning runs. These same streams, and the same areas within the streams, are sampled annually, thus establishing an index study area. It is believed that salmon production from the index study area is generally indicative of production from all Southeastern Alaska pink salmon streams.

Sampling intensity was changed from the rate of one sample per 1,000 square feet of study area to a rate that depends on the length and width of a spawning riffle. This has reduced the number of samples per area in most instances but we feel that it will not affect results.

In 1971 pre-emergent field work began the last week in February and continued into the second week of April. Geographical progression of sampling was as usual from Ketchikan and Sitka, north and east to Petersburg and Juneau as streams thawed. A total of eight crews worked throughout Southeastern Alaska sampling 86 streams. Winter weather conditions were near normal and did not appear to have any unusual effect on survival.

Of the 86 streams sampled, 42 were located in the southern half and 44 in the northern half. The total of 4,000 samples collected was less than that of the three previous years because of the changes in sampling intensity. However it is believed that the reduced sample did not significantly affect the year to year comparability of pre-emergent fry densities. The recent changes in sampling procedures to sampling only prime riffle areas may in some streams have increased the fry values in relation to past years. However, this increase is considered minimal.

Fry development at the end of March appeared to be normal in comparison with past years and there was no apparent early migration of fry which may have been missed by sampling.

The 1971 pre-emergent fry index for southern Southeastern was the highest for all sampling years and the index for northern Southeastern was the second highest for the respective areas (Table 3).

Table 3. Number of pink salmon alevins, sample size and unweighted fry indices per square meter by district for Southern and Northern Southeastern Alaska, 1966-1971.

Southern Southeastern

	1966			1967			1968		
	Alevins	Digs	Fry 1/ Index	Alevins	Digs	Fry Index	Alevins	Digs	Fry Index
District	No.	No.	No. /m ^{2}	No.	No.	No./m ^{2}	No.	No.	No./m
1	2,201	170	64.7	3,485	201	86.7	10,898	918	59.3
2	4,587	105	218.4	3,454	150	115.1	4,004	264	75.8
3	4,578	337	67.9	19,698	450	218.9	13,568	735	92.3
5	604	80	37.7	---	---	---	4,784	220	108.7
6	1,325	230	28.8	8,814	210	209.8	5,452	372	73.3
7	---	---	---	11,965	290	206.3	8,855	326	135.8
Totals	13,295	922	72.1 2/	48,380	1,342	108.2	47,561	2,835	83.9

	1969			1970			1971		
	Alevins	Digs	Fry Index	Alevins	Digs	Fry Index	Alevins	Digs	Fry Index
District	No.	No.	No./m ^{2}	No.	No.	No./m ^{2}	No.	No.	No./m
1	12,177	705	86.4	20,486	930	110.1	8,345	455	91.7
2	7,477	309	121.0	13,111	305	214.9	3,697	220	84.0
3	21,071	665	158.4	17,877	815	109.7	24,254	650	186.5
5	4,585	232	98.8	4,084	246	83.0	8,517	249	171.0
6	11,681	430	135.8	7,262	381	95.3	6,260	265	118.0
7	9,895	286	173.0	10,082	328	153.7	9,766	280	174.4
Totals	66,886	2,627	126.8	72,902	3,005	121.3	60,839	2,119	143.5

(Continued)

Table 3. Number of pink salmon alevins, sample size and unweighted fry indices per square meter by district for Southern and Northern Southeastern Alaska, 1966-1971 (continued).

Northern Southeastern

District	1966 Alevins No.	1966 Digs No.	1966 Fry[1] Index No./m^2	1967 Alevins No.	1967 Digs No.	1967 Fry Index No./m^2	1968 Alevins No.	1968 Digs No.	1968 Fry Index No./m^2
9	---	---	---	3,419	128	137.5	6,698	277	120.9
10	2,325	84	138.4	7,192	139	258.7	4,140	517	40.0
11	522	40	65.3	2,758	120	114.9	2,958	443	33.4
12	5,702	224	127.3	14,424	319	226.1	7,253	650	55.8
13	1,599	186	43.0	10,787	434	124.3	14,915	931	80.1
14	5,813	120	242.2	3,967	105	188.9	5,917	437	67.7
Totals	15,961	570	140.0[2]	42,647	1,245	171.3	41,881	3,255	64.3

District	1969 Alevins No.	1969 Digs No.	1969 Fry Index No./m^2	1970 Alevins No.	1970 Digs No.	1970 Fry Index No./m^2	1971 Alevins No.	1971 Digs No.	1971 Fry Index No./m^2
9	5,805	207	140.2	9,099	321	141.7	8,586	205	209.4
10	11,522	321	179.5	7,357	452	81.4	11,570	255	226.8
11	8,618	375	114.9	4,675	396	59.0	7,855	180	218.2
12	17,896	543	164.8	16,950	605	140.1	19,026	369	257.8
13	7,589	710	53.4	12,467	892	69.9	10,065	628	80.1
14	7,152	366	97.7	16,525	410	201.5	3,145	244	64.4
Totals	58,582	2,522	116.1	67,073	3,076	109.0	60,247	1,881	160.1

1/ Each dig encompasses .2 square meter; therefore, fry/meter^2 equals 5(fry/sample).

2/ Independently calculated.

Estimated 1972 Pink Salmon Return

The 1972 forecast for Southeastern Alaska is 26.6 million pink salmon. This estimate is obtained by relating past fry indices (Appendix A) for southern and northern Southeastern Alaska to corresponding returns of adult pink salmon (Figures 4 and 5). Resulting regression equations (see computations - Appendix B) indicate that for southern Southeastern the return in 1972 should be about 13.7 million pinks, but may vary from a low of about 10.4 million to a high of 17.1 million. In northern Southeastern the return should be about 12.9 million but may vary from a low of 7.1 million to a high of 18.7 million.

It should be noted from Figures 4 and 5 that the relationship between pre-emergent fry densities and corresponding adult returns does not appear to be linear over the entire range of fry densities. This is especially apparent in the lower range of fry densities, when projection of the regression lines through the x-axis would result in apparent estimates of no adult returns from substantial fry densities. Use of regression lines through the origin is not justified by the data, especially for southern Southeastern. However, for the range of data available and for the purpose of forecasting the 1972 returns the use of linear relationships is adequate.

When forecasting annual pink salmon runs on the basis of pre-emergent fry densities, a number of factors are responsible for the differences which occur between forecasts and actual returns. Some major sources of variability are: (1) random selection of sample points within streams, (2) variable contributions of index streams to total production, (3) variable estuarine and ocean mortalities and (4) errors in estimating actual total returns as a result of errors in estimating commercial harvest and escapements. To provide some measure of 'normal' or 'expected' variability between forecast and actual return, range forecasts are also made. Range forecasts, often referred to as confidence interval estimates, provide an estimate of the probable range within which the return will fall together with a measure of the probability that actual returns will fall within the predicted range.

The range forecasts presented in this report are interpreted to indicate that in approximately 8 years out of 10, actual returns would be expected to fall within the predicted ranges if the same forecasting techniques are used. The 1972 range forecasts of 10.1 - 17.4 million for southern Southeastern and 7.1 - 18.7 for northern Southeastern are admittedly wide, but because only five observations (years' data) are available on which to base the forecasts and considering the complexity of the sampling problems encountered, such variation should be expected. The width of future forecast ranges can be expected to decrease as additional data becomes available and as improvements are made in the sampling design.

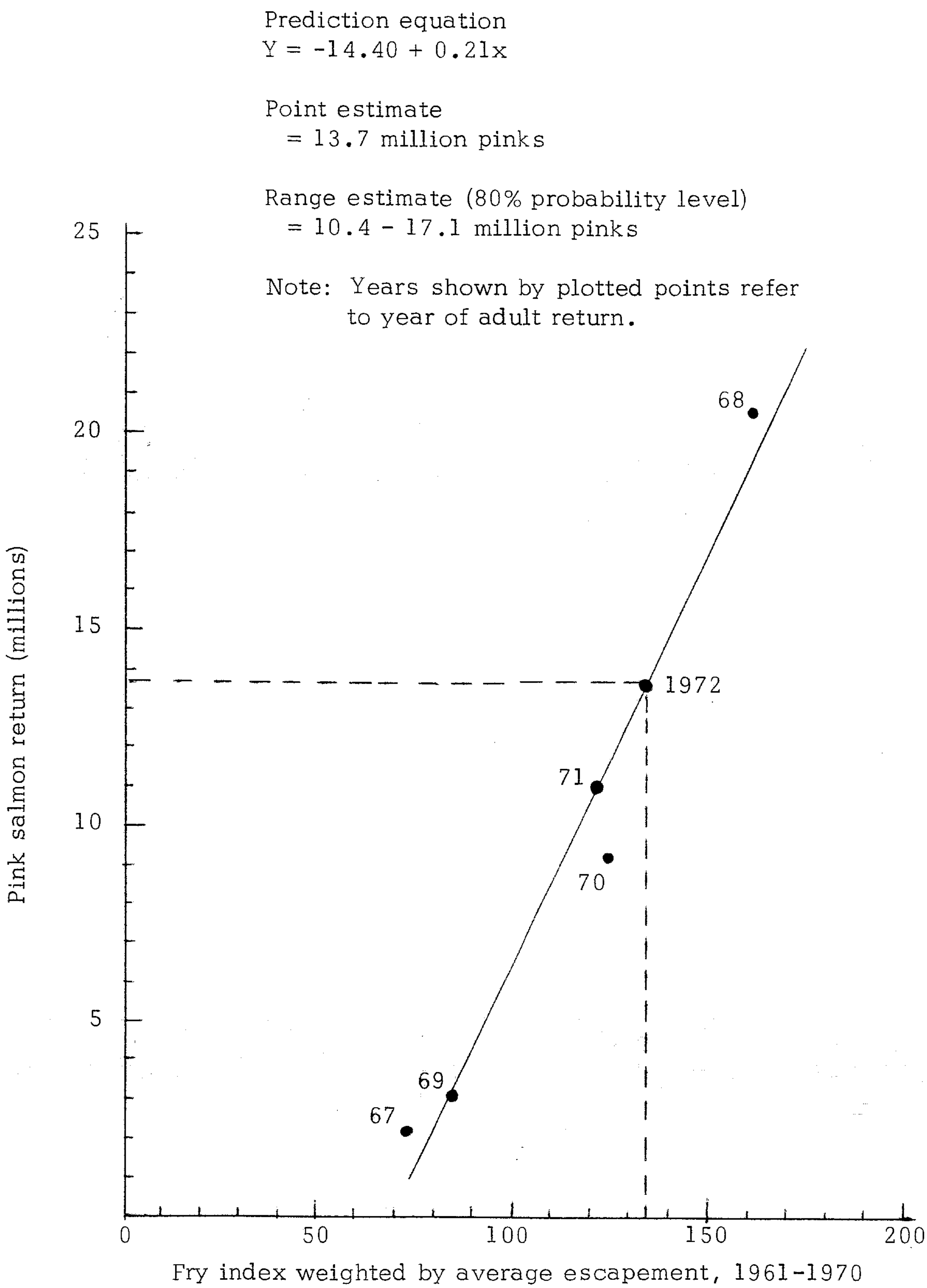


Figure 4. Forecast of the 1972 return of pink salmon to southern Southeastern Alaska.

Prediction equation
$Y = -2.23 + .08x$

Point estimate
= 12.9 million pinks

Range estimate (80% probability level)
= 7.1 - 18.7 million pinks

Note: Years shown by plotted points refer
to year of adult return.

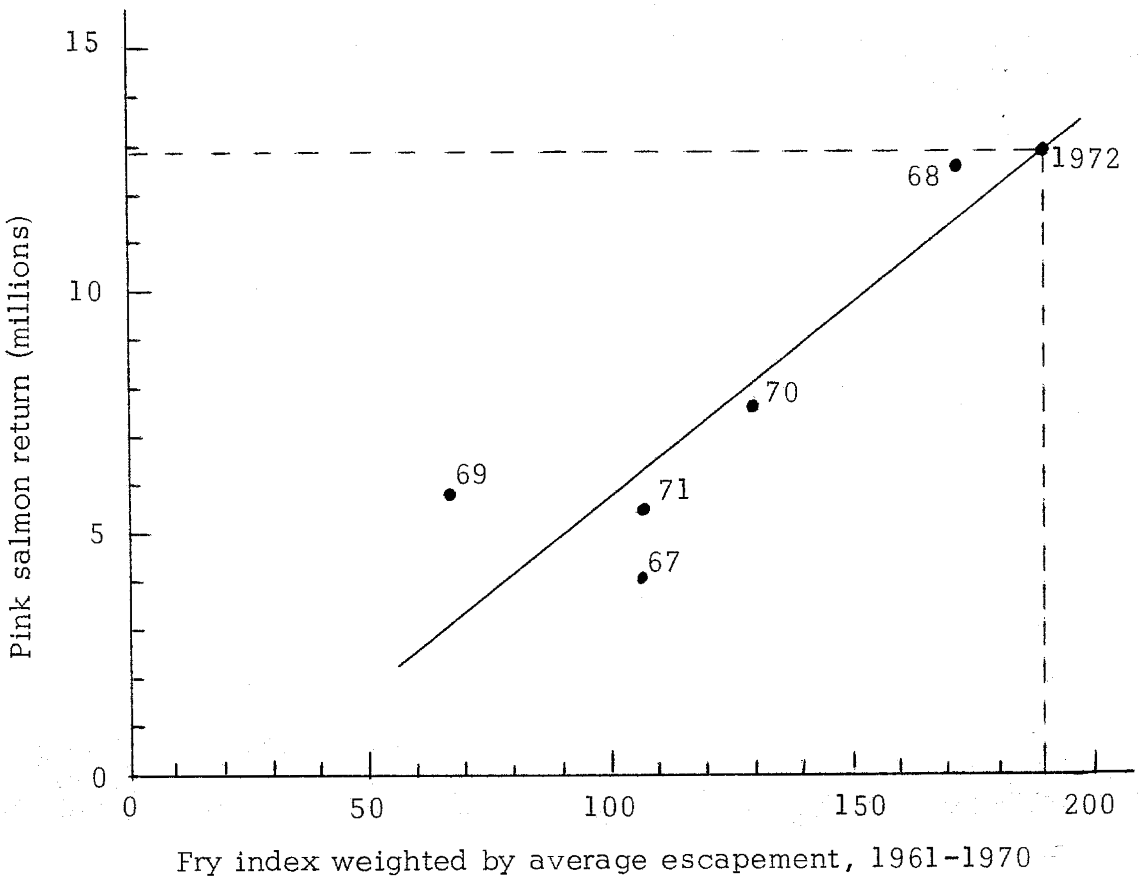


Figure 5. Forecast of the 1972 return of pink salmon to northern Southeastern Alaska.

1972 Escapement Goals and Expected Harvest Levels

Having developed a forecast of anticipated run size in 1972, it is essential to develop a pre-season estimate of the allowable harvest if the actual run is of the forecasted magnitude. Estimates of allowable harvest depend on the escapement goals established. As mentioned above, studies are being intensified to determine escapement goals consistent with the achievement of maximum sustained harvest of Southeastern Alaska pink salmon studies.

Production potential was demonstrated during the period 1920-1940 by most of the major salmon fisheries in the state, but because of the depressed state of the stocks at the time of statehood the basic management strategy since 1960 has been to increase escapement levels whenever possible until optimum levels are reached.

Only limited data are presently available for the estimation of optimum escapement levels for Southeastern Alaska pink salmon, but annual escapement goals should not be construed to necessarily be estimates of optimum escapements which will remain unchanged. Changes in escapement goals can be expected to occur as additional information becomes available on the carrying capacity of pink salmon spawning areas. The necessity to manage salmon runs each year requires that annual escapement goals be established on the basis of the best information available.

Present escapement goals are based on the escapement history of major producing streams for the past 10 year period. The size of the escapement, the distribution of spawners and subsequent fry densities and returns to each stream give some indication of the production capabilities of each stream and district.

Spawning gravel area has been measured in approximately fifteen streams throughout Southeastern Alaska, providing another basis for estimating carrying capacity in some more important salmon streams.

Escapement goals for 1972 are approximately 6 million pink salmon for southern Southeastern and 4 million for northern Southeastern. These goals are based in part on the 1972 returns being similar, both in total magnitude and distribution, to the 1972 forecast.

The 1972 forecast of total returns in conjunction with these escapement goals indicates anticipated harvest of approximately 7.7 million pink salmon for southern Southeastern and 8.9 million for northern Southeastern. Data on forecasts, escapement goals and expected harvest levels is summarized in Table 4.

Table 4. 1972 Southeastern Alaska pink salmon run forecast by timing segment. (Numbers of fish in millions).

	Forecasted Return		Escapement Goals		Probable Harvest	
Northern Southeastern	Point	Range 1/	Point	Range 2/	Point	Range 3/
Early Run	8.6		1.7		6.9	
Middle Run	1.7		0.9		0.8	
Late Run	2.6		1.4		1.2	
Subtotals	12.9	7.0-18.7	4.0	3.0-5.0	8.9	3.0-14.3
Southern Southeastern						
Early Run	4.6		1.1		3.5	
Middle Run	3.8		2.9		0.9	
Late Run	5.3		2.0		3.3	
Subtotals	13.7	10.4-17.1	6.0	4.5-7.5	7.7	4.4-11.1
Total Southeastern	26.6	17.4-35.8	10.0	7.5-12.5	16.6	7.4-25.4

1/ Ranges presented for the forecasted returns are 80 percent confidence intervals. Range estimates are not computed for the runs by timing segment.

2/ Ranges presented for the escapement goals represent the point escapement goal ± 25 percent.

3/ The probable harvest ranges are obtained from the range of forecasted total returns and the point escapement goals.

The total 1972 escapement goal of 10 million pink salmon for Southeastern Alaska represents an increase of several million over the goals of recent years. This increase is the result of additional analysis of data on the carrying capacity of Southeastern streams as described above. The goal of 10 million spawners (i.e., an escapement index of 10 million spawners) appears consistent with the estimated maximum sustainable harvest of 25-30 million pink salmon for Southeastern Alaska. From the 1960-71 data presented in Table 1, the average rate of adult return per parent spawner is approximately 3.6. The fact that this rate is lower than rates observed for other pink salmon stocks may be due in part to the use of escapement indices rather than estimates of total escapement in Southeastern. Rates of actual total return per actual parent spawner have been observed as high as 5 or 6. Using the rate of 3.6 in conjunction with the estimated maximum sustainable harvest level of 25-30 million indicates that in order to achieve this level of harvest, escapement indices in the range of 9.6-11.5 million would be required. The fact that the rate of adult return per parent spawner tends to decrease with increasing spawner density may require additional adjustments in escapement goals as more data becomes available from larger returns.

When the escapement level is raised to 10 million fish some streams may have what appears to be an "over-escapement" while others will remain depleted for several brood cycles until the population can build back to optimum size. This may be pronounced as escapements are initially increased to higher levels. Then, because Southeastern pink salmon fisheries are necessarily managed for mixed stocks, reduction in precision associated with that management procedure necessitates large escapements in some streams so that even moderate escapements will be realized in others.

It is impossible to regulate escapements to specific streams or bays because many salmon are intercepted up to 100 miles from their destination. Until more is known of the movements and timing of runs, precise management to allow proper escapement will be a problem of concern equal to the one of actually determining how many spawners are needed in the streams for maximum production.

Estimated Returns for Early, Middle and Late Run Segments

It is necessary to know the magnitude of the pink runs by different timing segments so precise management can ensure that proper harvest rates are achieved for each segment. The northern and southern area forecasts are broken down further into timing segments based on fry densities and the relative escapement levels of streams that are grouped into each segment.

For the purpose of this forecast the timing of runs is based on the time fish enter and spawn in their home streams. Most of the information on timing was provided by Area Management Biologists throughout Southeastern Alaska. Timing to spawning streams is divided into three segments -- early (prior to August 10); middle (August 10 to September 1); and late (September 1 and later). Some difficulty was encountered in grouping streams because of the overlap in the timing of runs to many streams. Preliminary stream groupings were used to forecast the 1972 returns by timing (Figure 6).

The estimated size of runs by timing is based on the total predicted return of 13.7 million to southern and 12.9 million to northern Southeastern. The timing through the established fishing areas can be inferred from the timing of escapements into the streams. For instance, in northern Southeastern timing of runs through the Icy Strait fishery can be grouped as: early (prior to mid-July); middle (mid-July to late July); and late (late July to early August).

The 1972 escapement goals and estimated catch for each timing segment have been established (Table 4) as based upon estimates of total expected return. The escapement goals to early, middle and late streams were calculated by estimating the optimum escapement of all major surveyed streams, separating them into early, middle and late and determining the percentage contribution of each segment to the total. The percentages were then applied to arrive at the total desired escapement of 6.0 million for the South and 4.0 million for the North.

Returns to early run streams are expected to be relatively strong and those returning to middle run streams weak in both northern and southern Southeastern. The late run streams in the northern area are expected to have relatively weak return while those of the south should have good returns.

The magnitude of runs by timing may be misleading. For example in northern Southeastern a surplus of about 1.0 million pinks are expected in the late run; however most of the late run streams on the west coast of Chichagof and Baranof Islands will have no surplus. In southern Southeastern a surplus of 1.2 million middle run pinks is expected even though many middle run streams are expected to have very poor showings. This will be evident when we examine the district forecasts.

Estimated 1972 District Returns

The pink salmon fishery can be better managed when data are available regarding an estimate of expected returns to each management district. The expected 1972 returns by district (Table 5) were determined by weighting the

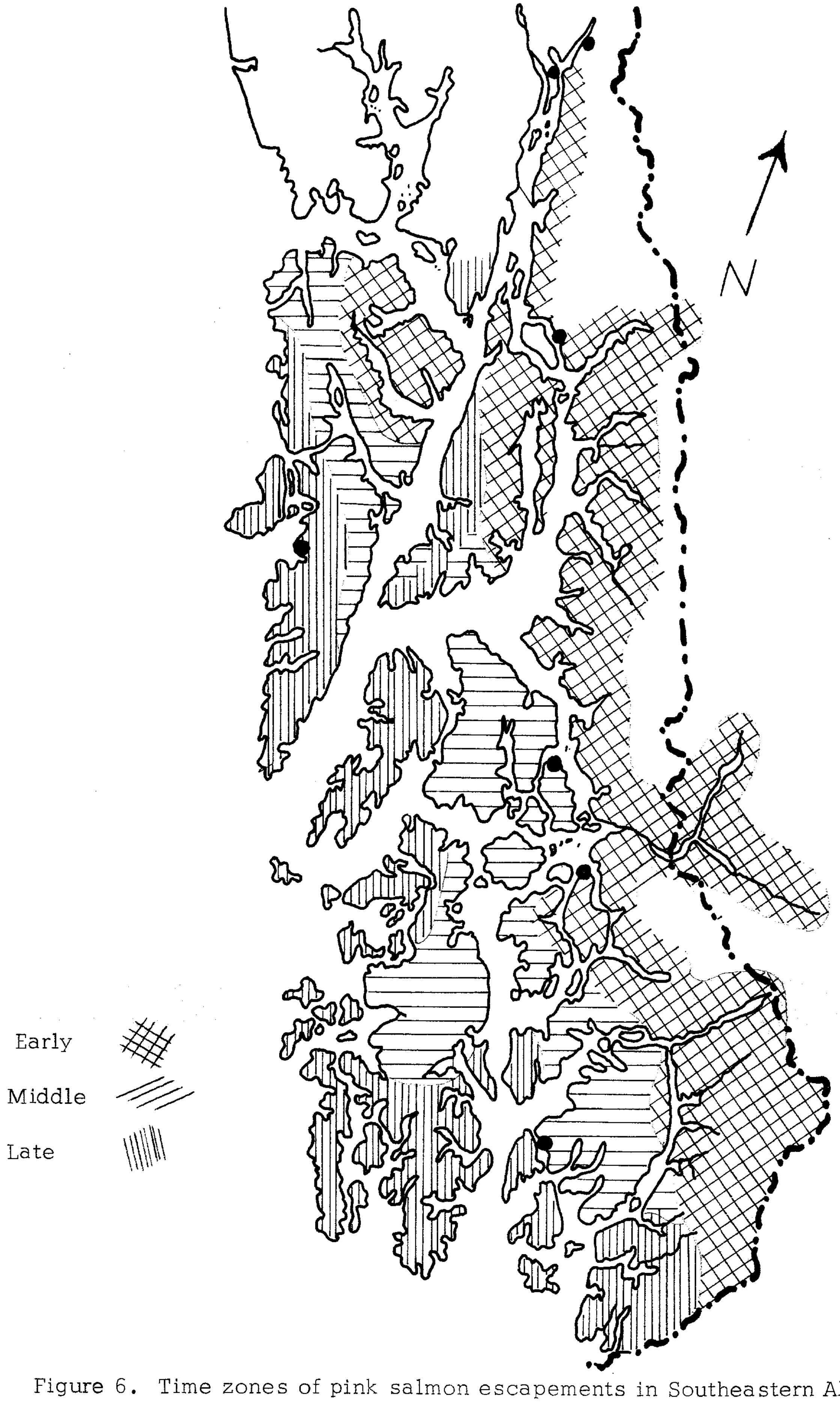


Figure 6. Time zones of pink salmon escapements in Southeastern Alaska used for 1972 timing forecasts.

Table 5. 1972 Southeastern Alaska district pink salmon forecast 1/.

Southern Southeastern

District	1970 Escapement	Percent total escapement A	Fry density per meter^2 B	A x B	Percent 1972 return run	1972 return 2/
1	1,779	43.4	91.7	3,979.8	29.9	4.1
2	224	5.4	84.0	453.6	3.4	0.5
3	1,261	30.8	186.5	5,744.2	43.2	5.9
5	195	4.8	171.0	820.8	6.2	0.9
6	311	7.6	118.0	896.8	6.8	0.9
7	330	8.0	174.4	1,395.2	10.5	1.4
Total	4,100	100.0		13,290.4	100.0	13.7

Northern Southeastern

District	1970 Escapement	Percent total escapement A	Fry density per meter^2 B	A x B	Percent 1972 return run	1972 return 2/
9	363	16.2	209.4	3,392.3	16.9	2.2
10	525	23.4	226.8	5,307.1	26.4	3.4
11	411	18.3	218.2	3,993.1	19.9	2.5
12	513	22.9	257.8	5,903.6	29.4	3.8
13	349	15.5	80.1	1,241.6	6.2	0.8
14	82	3.7	64.4	238.3	1.2	0.2
Total	2,243	100.0		20,076.0	100.0	12.9

1/ Excludes Districts 4, 8, and 15, which have contributed a total of about 500,000 pinks annually in recent years.

2/ Total returns derived earlier and applied independently as the base from which district returns were calculated.

percent of the total 1970 escapement returning to each district by the subsequent alevin indices and then applying these percentages to the total run prediction.

Districts 4, 8, and 15 are not included in the forecasts because of inadequate escapement data and no pre-emergent data. Based on existing escapement estimates, these three districts together probably have been producing about 500,000 pinks annually in recent years.

This further breakdown indicates that some geographical areas of weak returns are not indicated by the timing predictions. The desired escapement level for each district based on past escapement observations since 1960 (Table 6) indicates the harvestable surplus of pinks destined for each district based on the predicted total return. Pink salmon returns to Districts 2, 13 (outside Baranof and Chichagof Islands in particular), and 14 are expected to be extremely weak and every attempt should be made to protect these runs. Weak returns can also be expected to Districts 5 and 6. Another area expected to have poor returns and that is not apparent in the district forecasts is the area from Kosciusko Island south to Klawak Inlet in District 3.

SUMMARY

The 1972 forecast, based on pre-emergent fry abundance, estimates a return of 13.7 million pink salmon to southern Southeastern and a return of 12.9 million to northern Southeastern for a total return of 26.6 million pinks.

A linear regression analysis was used to arrive at a prediction equation for the 1972 forecast. The limited years fry-return relationship data and the nature of regression analysis resulted in forecast range estimates that are quite wide. The range for southern Southeastern is 10.4 million to 17.1 million and the range for northern Southeastern is 7.1 million to 18.7 million pink salmon. These ranges should narrow as more data become available.

Forecasts based on a cursory analysis of weather data corroborate the fry index forecasts, but suggest that the northern Southeastern return may be closer to 10 million.

Estimated returns by timing indicate good runs to the early streams throughout Southeastern, but generally poor runs to the late streams except those on the west coast of Prince of Wales Island. District return estimates further indicate that although the total magnitude of the run will be good, returns to certain districts will be very weak.

Table 6. 1972 district escapement goals and allowable harvest. (Numbers of salmon in millions).

Southern Southeastern

District	Forecasted return	Escapement goals	Allowable harvest
1	4.1	2.0	2.1
2	0.5	0.6	(-0.1) 1/
3	5.9	1.7	4.2
5	0.9	0.5	0.4
6	0.9	0.6	0.3
7	1.4	0.6	0.8
Total	13.7	6.0	7.7

Northern Southeastern

District	Forecasted return	Escapement goals	Allowable harvest
9	2.2	0.6	1.6
10	3.4	1.0	2.4
11	2.5	0.5	2.0
12	3.8	0.6	3.2
13	0.8	0.8	0.0
14	0.2	0.5	(-0.3) 1/
Total	12.9	4.0	8.9

1/ Indicates zero harvest.

Assuming a fair degree of accuracy in the 1972 forecast, the catches in the southern and northern areas of Southeastern Alaska should amount to approximately 7.7 million and 8.9 million, respectively.

When forecasting by timing and district the assumption must be stated that the total forecast for the northern and southern sections will be correct only if the estuarine and ocean mortality of the individual district stocks or time segments are not higher or lower than those affecting the total returning runs. Also, if total returns occur in the lower or higher range of the forecast the percentage contribution may be substantially correct but the number returning in each timing category or to each district would of course be lower or higher.

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APPENDIX

Appendix A. Pre-emergent fry densities per square meter weighted by 5 year average escapement. (Years shown refer to year of pre-emergent fry sampling.)

Southern Southeastern

	1966			1967		
	Ave. escapement 1961-65	Alevin density		Ave. escapement 1962-66	Alevin density	
District	A	B	A x B	A	B	A x B
1	1,008.4	64.7	65,243.5	1,193.4	86.7	103,467.8
2	322.8	218.4	70,499.5	425.6	115.1	48,988.6
3	905.4	67.9	61,476.7	1,117.0	218.9	244,511.3
5	378.4	37.7	14,265.7	---	---	---
6	489.4	28.8	14,094.7	488.2	209.8	102,424.4
7	---	---	---	460.6	206.3	95,021.8
Total	3,104.4		225,580.1	3,684.8		594,411.9
weighted fry index		72.6			161.3	

Northern Southeastern

	1966			1967		
	Ave. escapement 1961-65	Alevin density		Ave. escapement 1962-66	Alevin density	
District	A	B	A x B	A	B	A x B
9	---	---	---	476.8	137.5	65,560.0
10	366.0	138.4	50,654.4	428.4	258.7	110,827.1
11	196.2	65.3	12,811.9	221.4	114.9	25,438.9
12	336.4	127.3	42,823.7	357.8	226.1	80,898.6
13	743.0	43.0	31,949.0	697.0	124.3	86,637.1
14	259.0	242.2	62,729.8	232.2	188.9	43,862.6
Total	1,900.6		200,968.8	2,413.6		413,224.3
weighted fry index		105.7			171.2	

Appendix A (cont.).

Southern Southeastern

District	1968 Ave. escapement 1963-67 A	1968 Alevin density B	1968 A x B	1969 Ave. escapement 1964-68 A	1969 Alevin density B	1969 A x B
1	1,036.8	59.3	61,482.2	1,208.0	86.4	104,371.2
2	363.8	75.8	27,576.0	399.0	121.0	48,279.0
3	1,004.8	92.3	92,743.0	1,071.0	158.4	169,646.4
5	365.8	108.7	39,762.5	385.2	98.8	38,057.8
6	411.8	73.3	30,184.9	428.6	135.8	58,203.9
7	383.4	135.8	52,065.7	353.0	173.0	61,069.0
Total	3,566.4		303,814.3	3,844.8		479,627.3
weighted fry index		85.2			124.8	

Northern Southeastern

District	1968 Ave. escapement 1963-67 A	1968 Alevin density B	1968 A x B	1969 Ave. escapement 1964-68 A	1969 Alevin density B	1969 A x B
9	454.8	120.9	54,985.3	481.0	140.2	67,436.2
10	385.2	40.0	15,408.0	542.0	179.5	97,289.0
11	210.0	33.4	7,014.0	239.0	114.9	27,461.1
12	382.8	55.8	21,360.2	338.8	164.8	55,834.2
13	753.0	80.1	60,315.3	515.6	53.4	27,533.0
14	255.8	67.7	17,317.7	152.0	97.7	14,850.4
Total	2,441.6		176,400.5	2,268.4		290,403.9
weighted fry index		72.3			128.0	

Appendix A (cont.).

Southern Southeastern

	1970			1971		
	Ave. escapement 1965-69	Alevin density		Ave. escapement 1966-70	Alevin density	
District	A	B	A x B	A	B	A x B
1	1,037.2	110.1	114,195.7	1,284.2	91.7	117,761.1
2	356.2	214.9	76,547.4	356.8	84.0	29,971.2
3	929.0	109.7	101,911.3	997.8	186.5	186,089.7
5	341.4	83.0	28,336.2	294.0	171.0	50,274.0
6	335.0	95.3	31,925.5	309.8	118.0	36,556.4
7	330.2	153.7	50,751.7	337.8	174.4	58,912.3
Total	3,329.0		403,667.8	3,580.4		479,564.7
weighted fry index		121.3			133.9	

Northern Southeastern

	1970			1971		
	Ave. escapement 1965-69	Alevin density		Ave. escapement 1966-70	Alevin density	
District	A	B	A x B	A	B	A x B
9	462.6	141.7	65,550.4	439.8	209.4	92,094.1
10	505.0	81.4	41,107.0	559.0	226.8	126,781.2
11	230.0	59.0	13,570.0	288.8	218.2	63,016.2
12	365.2	140.1	51,164.5	399.8	257.8	103,068.4
13	569.6	69.9	39,815.0	465.4	80.1	37,278.5
14	184.6	201.5	37,196.9	129.2	64.4	8,320.5
Total	2,317.0		248,403.8	2,282.0		430,558.9
weighted fry index		107.2			188.7	

Appendix B. Southeastern Alaska pink salmon escapement indices by district in thousands of fish (1961-1970) 1/ .

Southern Southeastern

District	Year 1961	1962	1963	1964	1965	1966
1	551	1,225	1,186	1,536	544	1,476
2	136	470	224	563	221	650
3	496	826	1,173	1,115	917	1,554
4	11	18	9	19	9	19
5	298	479	271	412	432	453
6	473	542	352	643	437	467
7	256	557	586	276	292	592
8	134	118	114	181	92	191
Totals	2,355	4,235	3,915	4,745	2,944	5,402

District	Year 1967	1968	1969	1970	Annual average
1	442	2,042	682	1,779	1,146
2	161	400	349	224	340
3	265	1,504	405	1,261	952
4	12	68	40	42	25
5	261	418	143	195	336
6	160	436	175	311	400
7	171	434	162	330	366
8	34	103	58	82	111
Totals	1,506	5,405	2,014	4,224	3,674

(continued)

Appendix B (cont.).

Northern Southeastern

District	1961	1962	1963	1964	1965	1966
9	434	470	404	452	477	581
10	332	424	280	539	255	644
11	260	145	270	189	117	386
12	355	98	644	245	340	462
13	731	280	1,392	442	870	501
14	207	63	589	77	359	73
15	10	10	10	10	4	6
Totals	2,329	1,490	3,589	1,954	2,422	2,653

District	1967	1968	1969	1970	Annual average
9	360	535	360	363	444
10	208	1,064	354	525	463
11	88	415	144	411	243
12	223	424	377	513	368
13	560	205	712	349	604
14	181	70	240	82	194
15	16	9	10	23	11
Totals	1,636	2,722	2,197	2,266	2,326

1/ Escapement indices are a measure of the relative magnitude of escapement to Southeastern Alaska streams. They do not represent actual total escapements.

Appendix C. Linear regression analysis to determine point and range forecast estimates for 1972.

In the following analysis

X = pre-emergent fry density expressed in fry per square meter

Y = subsequent total return of adult pink salmon expressed in millions

SOUTHERN SOUTHEASTERN

Brood year	X	Y	$(X-\bar{X})$	$(X-\bar{Y})$	$(X-\bar{X})^2$	$(X-\bar{X})(Y-\bar{Y})$	$(Y-\bar{Y})^2$
1965	72.6	2.2	-40.44	- 7.14	1635.39	288.74	50.98
1966	161.3	20.6	48.26	+11.26	2329.03	543.41	126.79
1967	85.2	3.2	-27.84	- 6.14	775.07	170.94	37.70
1968	124.8	9.7	+11.76	+ .36	138.30	4.23	.13
1969	121.3	11.0	+ 8.26	+ 1.66	68.23	13.71	2.76
Sums	565.20	46.70	0.00	0.00	4946.02	1021.03	218.36

$\bar{X}$ = 113.04

$\bar{Y}$ = 9.34

$$b = \frac{\Sigma (X-\bar{X})(Y-\bar{Y})}{\Sigma (X-\bar{X})^2} = \frac{1021.03}{4946.02}$$

b = .21

$a = \bar{Y} - b\bar{X}$

a = 9.34 - .21 (113.04)

a = -14.40

Y = -14.40 + 0.21X

Appendix C (cont.).

Point estimate

$$\hat{Y} = a + bX$$

$$\hat{Y} = -14.40 + 0.21(133.9)$$

$$\hat{Y} = -14.40 + 28.12$$

$$\hat{Y} = 13.72$$

Standard deviation from regression

$$s^2_{Y.X} = \frac{1}{n-2}\left[\Sigma (Y-\bar{Y})^2 - b\,\Sigma (X-\bar{X})(Y-\bar{Y})\right]$$

$$s^2_{Y.X} = \frac{1}{3}\left[218.36 - .21\,(1021.03)\right]$$

$$s^2_{Y.X} = 1.31$$

$$s_{Y.X} = \sqrt{1.31} = 1.15$$

Standard error of prediction

$$s_{Y.} = s_{Y.X}\sqrt{1 + \frac{1}{n} + \frac{(\hat{Y}-\bar{X})^2}{\Sigma (X-\bar{X})^2}}$$

$$s_{Y.} = 1.15\sqrt{1 + \frac{1}{5} + \frac{(13.72 - 113.04)^2}{4946.02}}$$

$$s_{Y.} = 1.15\sqrt{1 + \frac{1}{5} + 1.99}$$

$$s_{Y.} = 2.05$$

Prediction interval

$$\hat{Y} \pm t\,(\alpha/2,\, n-2)\, s_{Y.}$$

P = .90 (90 percent confidence interval)

$$13.72 \pm 2.353\,(2.05) = 13.72 \pm 4.82 = 8.90 \text{ to } 18.58$$

P = .80 (80 percent confidence interval)

$$13.72 \pm 1.638\,(2.05) = 13.72 \pm 3.36 = 10.36 \text{ to } 17.08$$

Appendix C (cont.).

NORTHERN SOUTHEASTERN

Brood year	X	Y	$(X-\bar{X})$	$(Y-\bar{Y})$	$(X-\bar{X})^2$	$(X-\bar{X})(Y-\bar{Y})$	$(Y-\bar{Y})^2$
1965	105.7	4.1	-11.18	-3.02	124.99	33.76	9.12
1966	171.2	12.6	+54.32	+5.48	2950.66	297.67	30.03
1967	72.3	5.8	-44.58	-1.32	1987.38	58.85	1.74
1968	128.0	7.6	+11.12	+0.48	123.65	5.34	0.23
1969	107.2	5.5	- 9.68	-1.62	93.70	15.68	2.62
Sums	584.4	35.6	0.00	0.00	5280.38	411.30	43.74

$$\bar{X} = 116.88$$

$$\bar{Y} = 7.12$$

$$b = \frac{\Sigma (X-\bar{X})(Y-\bar{Y})}{\Sigma (X-\bar{X})^2} = \frac{411.30}{5280.38}$$

$$b = .078$$

$$a = \bar{Y} - b\bar{X}$$

$$a = 7.12 - .08\,(116.88)$$

$$a = -2.23$$

$$Y = -2.23 + .08X$$

Appendix C (cont.).

Point estimate

$$\hat{Y} = a + bX$$

$$\hat{Y} = -2.23 + .08\,(188.67)$$

$$\hat{Y} = -2.23 + 15.09$$

$$\hat{Y} = 12.86$$

Standard deviation from regression

$$s^2_{Y.X} = \frac{1}{n-2}\left[\Sigma\,(Y-\bar{Y})^2 - b\,\Sigma\,(X-\bar{X})(Y-\bar{Y})\right]$$

$$s^2_{Y.X} = \frac{1}{3}\left[43.74 - .078\,(411.30)\right]$$

$$s^2_{Y.X} = 3.89$$

$$s_{Y.X} = \sqrt{3.89} = 1.97$$

Standard error of prediction

$$s_{Y.} = s_{Y.X}\sqrt{1 + \frac{1}{n} + \frac{(\hat{Y}-\bar{X})^2}{\Sigma\,(X-\bar{X})^2}}$$

$$s_{Y.} = 1.97\sqrt{1 + \frac{1}{5} + \frac{(12.86 - 116.88)^2}{5280.38}}$$

$$s_{Y.} = 1.97\sqrt{1 + \frac{1}{5} + 2.05}$$

$$s_{Y.} = 3.54$$

Appendix C (cont.).

Prediction interval

$$\hat{Y} \pm t(\alpha/2, n-2)\, s_Y.$$

P = .90 (90 percent confidence interval)

$$12.86 \pm 2.353\,(3.54) = 12.86 \pm 8.33 = 4.53 \text{ to } 21.19$$

P = 80 (80 percent confidence interval)

$$12.86 \pm 1.638\,(3.54) = 12.86 \pm 5.80 = 7.06 \text{ to } 18.66$$